TOBACCO SMOKE FILTER

Field of invention

The invention relates to a tobacco smoke filter for use with smokable devices, such as cigarettes. The tobacco smoke filter comprises a metal granulate including zinc or copper, preferably a granulate of a copper-zinc alloy.

Background of the invention

Technological progress in the world today has brought with it accompanying social and environmental problems. Among the latter, air pollution is dominant. Efforts are presently being made to elevate air fouling problems stemming from sources including industrial and engineering production, and exhaust from motorised vehicles. Stricter regulatory controls and laws have been imposed in order to safeguard society's health and the environment. The International Agency for Research on Cancer (IARC) currently lists 88 individual chemical agents as "Group 1 Human Carcinogens" (IARC monographs, Vols. 1-82, 1987) A substantial number of these agents exist in polluted air, which highlight the urgency for solving pollution problems.

Smoking constitutes another, albeit self-imposed, air pollution risk. Of the 88 chemical agents listed as carcinogens, at least 9 have been reported to occur in mainstream cigarette smoke as part of the tar or residue component which include metals such as cadmium, nickel, chromium, beryllium and arsenic. The other agents include toxic organic substances such as benzene, vinyl chloride, 2-napthyl-amine, and 4-aminobiphenyl. A different relative risk of lung cancer between smokers using filter and plain cigarettes has been indicated; the risk appears to be 36% lower in filter than in plain cigarette smokers. As filter cigarettes reduce the level of tar consumed by smokers, a relation between the level of tar consumed and risk of cancer is anticipated.

Over the last 40 years, the level of both tar and nicotine in cigarettes has decreased. Reducing the level of nicotine, may, however, encourage more frequent

smoking and in this way, ironically, raise the level of tar consumed. Several attempts to improve the capacity for removing harmful substances in tobacco filters have been made.

US 5,409,021 to Safaev et al. proposes a cigarette filter including a cellulose fiber member, an acetate fiber member, and further comprising lignin as an adsorbing substance.

US 5,746,231 to Lesser et al. teaches a tobacco smoke filter comprising a porous substrate having a humectant, such as sodium pyroglutamate or a copper-containin porphyrin, dispersed therein to absorb moisture from the tobacco smoke, thereby wet-filtering the tobacco smoke.

Still, there is a need for new filter systems in tobacco products which are able to significantly reduce harmful substances, such as the level of tar and heavy metals, without influencing the nicotine level.

Summary of the invention

We have now found that a metal granulate of copper, zinc, or a copper-zinc alloy, so-called RAM, may function as an effective filtering agent for removing hazardous content from tobacco smoke. More specifically, we have found that such a copper-zinc alloy is able to effectively bind a large number of substances classified as carcinogens or toxic agents. These include metals such as silver, cadmium, cobalt, chromium, copper, mercury, manganese, nickel, vanadium, zinc, and especially lead. In tobacco products such as cigarettes, for example, RAM has been found to reduce the heavy metal content in cigarette tar by 50-70 % after use.

According to a first aspect, the invention therefore relates to a tobacco smoke filter, for use in a smokable device comprising a body of tobacco, wherein said tobacco smoke filter comprises a metal granulate including zinc, copper, or a copper-zinc alloy.

Preferably, the tobacco smoke filter comprises a fibrous filter.

In one embodiment, wherein one end of said fibrous filter defines an inhalation end, and said metal granulate is disposed adjacent to an end of said fibrous filter opposite said inhalation end.

In one embodiment, said metal granulate is dispersed in said fibrous filter.

In one embodiment, said metal granulate is dispersed in a portion of said fibrous filter.

In one embodiment, said metal granulate is disposed between a first fibrous filter portion of said fibrous filter, and a second portion of said fibrous filter.

In one embodiment, said metal granulate comprises particles of zinc, copper, or a copper-zinc alloy, in a particle size range of 0.05-3 mm.

In one embodiment, said metal granulate comprises particles of zinc, copper, or a copper-zinc alloy, in a particle size range of 0.1-2 mm.

In one embodiment, said metal granulate is included with a mass in the range of 0.1-1 g.

In one embodiment, said metal granulate is redox alloy media (RAM).

According to a second aspect, the invention relates to a smokable device comprising a body of tobacco, wherein a tobacco smoke filter comprising a metal granulate including zinc, copper, or a copper-zinc alloy, according to any of the preceding claims 1-9, is affixed to said body of tobacco.

Brief description of the drawings

The invention will be described in greater detail below, with reference to the appended drawings, in which:

Figs 1 and 2 show the experimental set-up of filter tests performed on cigarettes, without and with a copper-zinc filter substance;

Fig. 3 illustrates a cigarette with a filter; and

Figs 4-7 illustrates different embodiments of implementation of a tobacco smoke filter according to the invention.

Detailed description of preferred embodiments

It has been known to use a fluid treating method for reducing hardness in water, by incorporating a bed of finely divided metal particulate matter comprising copper and/or zinc, or an alloy of copper and zinc. The metal particulate matter possesses a reduction-oxidation (redox) potential which, relative to the redox

potential of the undesirable constituents, favours spontaneous oxidation-reduction reactions between the metal and the undesirable constituents, which include bacteria. Such a method is e.g. known from US Patents 5,433,856 and 5,135,654 to Heskett. A filter medium known as "redox alloy medium (RAM)" is a high purity copper-zinc alloy, which has been employed in water purification. Such a RAM substance is available in different forms under the trademark KDF® from KDF Fluid Treatment Inc., to whom the aforementioned two patents are assigned.

Oxidation-reduction reactions using RAM allow removal of dissolved gases such as chlorine, hydrogen sulphide, methane from contaminated water. The same or related redox reactions in RAM also allow removal of soluble heavy metals, and prevention of hardness scale accumulation. RAM is commonly been used in conjunction with other filtration media. Additionally, RAM is reported to eliminate or reduce the level of microorganisms when redox reactions occurring produce a significant potential shift, which disrupt cellular membranes resulting in microbial death. Also, hydroxyl radicals and hydrogen peroxide, produced for example, during the oxidation of ferrous iron to ferric iron, are toxic to microorganisms.

Although US 5,135,654 teaches the potential of using RAM for both liquid fluid media as well as gaseous fluid media, the useful properties of RAM have been applied exclusively for water purification. However, the inventor of the present invention has found that metal particulate matter comprising copper and/or zinc, and preferably a copper-zinc alloy, has shown proven to be excellent also for removal of undesired substances in tobacco smoke.

The invention therefore relates to a tobacco smoke filter, comprising a metal particulate or granulate matter comprising copper or zinc, and preferably a copper-zinc alloy, such as a redox alloy media (RAM).

In a preferred embodiment, a RAM alloy is provided in particulate or granulate form and may have varying mesh size, from about 4 to about 400 mesh, based on US Standard screen sizes. A distribution of mesh size is anticipated to be present in the alloy granulate. The metal particulate matter comprising the alloy may be supplied as a free granulate, or in other alternate forms such as in aggregate porous bodies made by adhering the particulate matter onto porous bodies of any

shape, formed by techniques such as sintering or alternative processes wherein binders are utilized.

The ratio by weight of copper:zinc in the alloy may be about 25:75, about 50:50, about 40:60, about 25:75, or in a range there between, when used as described in this application. Typically, the particle size of the alloy is in the range of 0.05-3 mm, preferably in the range of 0.1-2 mm, with an apparent density in the range of 2-3 g/cm^3. The alloy is capable of binding/adsorbing/removing pollutants from air. Specifically, the tobacco smoke filter is capable of binding metals such as silver, cadmium, cobalt, chromium, copper, mercury, manganese, nickel, vanadium, zinc, and especially lead.

The zinc in the alloy is more reactive than copper and more electropositive. Within the alloy component, multitudes of granular high-purity bimetallic couples with copper as the permanent cathode and zinc as the sacrificial anode may be found. The metals are given a value of -0.76 volts and copper +0.36 volts. The net result is 1.12 volt difference with zinc as the electric donor. A number of elemental metals and metallic alloys will provide the redox potential.

In the case of reaction with a heavy metal, for example, lead (Pb), the reaction my be depicted as follows:

$$Cu/Zn_o + Pb^{2+}(NO_3)_2 = Zn/Cu/Pb_o + Zn^{2+}\ (NO_3)_2{}^{2-}$$

(where Cu represents copper, Zn represents zinc, Pb represents lead, $(NO_3)_2$ represents nitrate)

In the reaction, zinc loses 2 electrons (i.e, is oxidised), while lead gains 2 electrons (i.e., is reduced). Lead thus deposits on copper and replaces zinc, which goes into solution as ions.

One embodiment of the invention relates to a tobacco smoke filter including RAM, which removes pollutants through oxidation-reduction reactions between the RAM component and the pollutants found in the air which require removal, for example, cigarette tar or heavy metal pollutants, said reaction resulting in the deposition of the pollutants on the filter surface. The filter may then be regenerated by melting the alloy down, reshaping to the desired form and reusing.

In a variant of that embodiment, the employment of water, preferably steam,

accompanies the use of the device. In such an embodiment, the filter is supplied with water (heated or unheated) before or during use. The water may e.g. be supplied by means of spraying, condensation, or dripping, and it may be supplied prior to use of the filter, continuously during use of the filter, or intermittently during use of the filter at certain intervals. Some acceleration or enhancement of the redox reactions has been surmised, which might lead to an increase in the effectivity and productivity of the device. However, the presence of water is not per se necessary to the functioning of the invention.

An air cleaning device comprising a copper-zinc alloy may be used for all kinds of air cleaning when the pollutants as mentioned before are to be removed from air or other gases. In particular, the invention involves using a filter comprising a granulate form of copper, zinc, or a copper-zinc alloy, for removing filtering tobacco smoke. Such a filter may be used with a wall-mounted or ceiling-mounted vent, for filtering air passing from a smoke-contained area, such as a room, a smoking compartment, or a freestanding smoking cage. Preferably, an under pressure is applied to the vent, such that air and smoke in the smoke-contained area is sucked out and forced to pass the filter.

Tests made show that use of a filter comprising a granulate form of copper, zinc, or a copper-zinc alloy inhaled through the use of tobacco products allows the removal of the heavy metal content in tar of more than 50%, such as from about 50% to about 70 %, such as up to 90%. Using such a type of filter in an air cleaning device for filtering air from a smoke-contained will therefore also be efficient for removing such undesired substances from the vented air, which thereby reduces the risk for vented air to carry those substances to places where other people may be exposed.

Besides reducing the general tar level, the air cleaning device can remove specific heavy metals, such as silver, cadmium, cobalt, chromium, copper, mercury, manganese, nickel, vanadium, zinc, and especially lead. Some of these, especially the heavy metals, are known or suspected to be carcinogens. Thus, the filter both reduces the general tar level as well as removes metals known or suspected to be carcinogens.

Consequently, the invention relates in general to a tobacco smoke filter including a granulate form of copper and/or zinc, or a copper-zinc alloy. Such a filter may e.g. be used as an air cleaning device for use in a ventilation system.

According to a preferred embodiment, the invention relates to a tobacco smoke filter comprising a granulate form of copper, zinc, or a copper-zinc alloy, placed between tobacco and an inhalation end of a tobacco product. Fig. 3 illustrates a smoking device in the form of a cigarette 30, including a tobacco-filled portion 31, preferably wrapped in paper, and a fibrous filter 32 attached at one end of the tobacco-filled portion 20, likewise preferably wrapped in paper. An outer end of filter 32, opposite portion 20, defines an inhalation end of the smoking device 30. Typically, the fibrous filter 32 may comprise a cellulose fiber, an acetate fiber, or a combination thereof. The actual characteristics of the fibrous content of filter 32 is not essential for the invention, and several types of such fibrous filters are known in the art. According to this embodiment, the capability of removing tar and heavy metals from tobacco smoke is provided by means of incorporating a metal filter substance comprising a granulate form of copper and/or zinc, or a copper-zinc alloy.

Fig. 4 illustrates one specific embodiment of a tobacco smoke filter 40, comprising a first filter portion 41 at an inhalation end, i.e. the lower end in the drawing, comprising a fibrous substance, such as cellulose or acetate. The tobacco smoke filter 40 further comprises a second filter portion 42 including a metal granulate comprising copper, zinc, or an alloy of copper and zinc. The second filter portion 42 is located between the first filter portion 41 and a tobacco portion, positioned over second filter portion 42, such as in Fig. 3. The metal granulate may be disposed freely between the tobacco and the fibrous filter. Alternatively, the metal granulate may be supported on a fiber carrier or in a porous carrier body.

Fig. 5 illustrates an alternative embodiment of a tobacco smoke filter 50. In this embodiment, a filter 50 comprising a fibrous substance has a first filter portion 51 disposed at an inhalation end, and a second filter portion 52 disposed towards a tobacco-facing end of filter 50. The second filter portion of the fibrous substance includes a metal granulate comprising copper, zinc, or an alloy of copper and zinc, dispersed within the fibrous substance.

Fig. 6 illustrates yet another embodiment, which is a variant of the embodiment of Fig. 5. Instead of confining the metal granulate comprising copper, zinc, or an alloy of copper and zinc, to a portion of the fibrous filter 60, the metal granulate is dispersed within substantially the entire fibrous filter 60.

Fig. 7 illustrates an embodiment of a tobacco product filter 70, having a first fibrous substance filter portion 71 disposed at an inhalation end, and a second fibrous substance filter portion 72 disposed at its opposite, tobacco-facing, end. Said first 71 and second 72 fibrous substance filter portions may be of equal or different compositions, e.g. selected from cellulose or acetate. Furthermore, a third portion 73 of filter 70 is disposed between said first 71 and second 72 filter portions, and includes a metal granulate comprising copper, zinc, or an alloy of copper and zinc. Said metal granulate may be dispersed within a fibrous substance, or be freely disposed between the first 71 and second 72 filter portions.

In the tobacco smoke filter of the embodiments described with reference to Figs 3-7, the metal granulate comprising copper, zinc, or an alloy of copper and zinc is preferably included in a mass range of 0.1-1 g.

When smoke from a cigarette such provided with a metal granulate filter according to the invention is inhaled, contaminants such as silver, cadmium, cobalt, chromium, copper, mercury, manganese, nickel, vanadium, zinc, and especially lead, will bind to the RAM alloy and not be inhaled. However, at the same time, the filter comprising a granulate form of copper, zinc, or a copper-zinc alloy does not appear to reduce the nicotine level nor influence the function of suction from cigarettes. Therefore, the filter will not lead to increased smoking compared to cigarettes not provided with the inventive filter.

It should be noted that the tobacco smoke filter according to the invention need not necessarily be fixed to a body of tobacco, as illustrated in Fig. 3. The tobacco smoke filter may likewise be confined, or be devised to be placed, in a separate filter sleeve arranged to be applied to a smoking device, such as a filter cigarette, filter free cigarette, or a pipe.

Examples

An example is given below, which illustrates an embodiment of the invention as a tobacco smoke filter. This example is present to exemplify the invention; they are not, however, intended to limit in any way the invention as covered by the claims.

The experimental setup is shown in Figs 1 and 2. In Fig. Cigarettes 1 were smoked using a plastic tube 4 connected to the cigarettes 1 through a sleeve 2. A common filter only (in cigarette 1) was used as a control, as shown in Fig. 1. A test setup furthermore comprised a copper-zinc alloy (RAM) filter 5. The smoke was guided through the common filter of the cigarette and, when included, the RAM filter 5, and further through a test filter 4. Test filter 4 was weighed before and after smoking. The approximate amount of tar was calculated by the difference of filter weight before and after smoking. The results showed that the amount of tar inhaled from smoking one cigarette was reduced by 45%, when using a RAM filter with a granulate of a copper-zinc alloy. In the tests, a RAM filter of 0.5 g was used.

The tests have been made with a cigarette which is stated to contain 1 mg of tar, according to the cigarette box. Still, the tests that have been made show that the test filter increases in weight with between 3 and 5 mg after smoking, which shows a considerable absorption of tar due to the inclusion of the RAM filter. Weighing has been performed after a couple of hours, to ensure that absorbed water has properly evaporated in order not to add to the mass of the test filter.

Furthermore, the RAM filter has also proven to remove heavy metal from tobacco smoke. A comparison of the amount of heavy metal present in a smoked and an unsmoked RAM filter is given in Table 1 below.

Metals	Smoked RAM (mg/kg*)	RAM (mg/kg)
Silver (Ag)	<9	<9
Cadmium (Cd)	<0.3	<0.3
Cobalt (Co)	<0.3	<0.3
Chromium (Cr)	<0.6	<0.6
Mercury (Hg)	<3	<3

Manganese (Mn)	<1	<1
Nickel (Ni)	16.1	26.6
Lead (Pb)	51.5	<3
Vanadium (V)	<0.3	<0.3

(* i.e., mg (heavy metal)/kg (filter membrane))

Table 1

The results given in Table 1 indicate that smoking increases the amount of heavy metal content, especially lead (Pb), deposited in the cigarette filters when RAM filters are used.

A comparison of the amount of heavy metal present in a smoked filter membrane with and without RAM is shown in Table 2 below.

Metals	Filter with RAM (mg/kg)	Filter without RAM (mg/kg)
Ag	<0.2	<0.09
Cd	0.163	0.207
Co	0.0629	0.140
Cr	1.25	0.551
Hg	<0.02	<0.01
Mn	0.587	2.45
Ni	0.977	0.495
Pb	1.22	0.246

Table 2

The results given in Table 2 indicate that a significantly greater amount of heavy metal, in particular lead, is trapped in the filter membranes comprising RAM.